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ROBERT VEITCH, B.Sc.

ENTOMOLOGIST TO
THE COLONIAL SUGAR REFINING COMPANY, LIMITED.

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The White Grubs of the Sugar Cane Soils of Fiji.

Introduction.

VARIOUS species of white grubs occur in many classes of soil in different parts of the world, but frequently a species is either so scarce or so little given to attacking living plant tissue that its presence exercises practically no effect on the crops, and indeed such a species is usually noticed by entomological investigators only; on the other hand certain species sometimes occur in such numbers and are so destructive to the underground portion of the plant that they are included among the most serious enemies of the agriculturist. Three species are known to live in the sugar-cane soils of Fiji and all three have been found attacking sugar-cane; the species in question are known to science as *Rhopaea vestita*, Arrow, *Rhopaea subnitida*, Arrow, and *Adoretus versutus*, Har. Each of these species will be dealt with separately, taking them in the order of their importance.

I.—The White Grub of Sandy Soils.

The white grub infesting sandy soils in Fiji is known to science as *Rhopaea vestita*, Arrow, and belongs to the family MELOLONTHIDAE in the COLEOPTERA. As is the case with most insects the life cycle consists of four stages, each of which appears to be quite different from the other three, the difference in appearance being so great that many people do not realise that they are only stages in the development of one and the same insect. These four stages are the egg, the larva, the pupa and the beetle; the egg hatches into the larva (known in this case as "the white grub"), which feeds for a number of months and then changes into the pupa which in its turn transforms to the beetle or perfect insect.

Life History. The Egg.

The elongate oval eggs (Plate I. ; Fig. 1) of this species are laid singly at a depth of 15 to 20 inches in the sandy soils close to the coast ; hence the grubs are most commonly found at Sigatoka, Enamanu, Esivo, Saweni and Drasa in the Lautoka mill district. This species has also been responsible for slight damage in Varoko fields in the Rarawai district ; the writer has no record of damage at any of the other mills, although it is perfectly possible that such damage may occur and has not yet been associated with the destructive activities of this pest. The eggs are found from May to October inclusive, but are most abundant in June and July ; when laid the eggs are about one-tenth of an inch in length but there is a distinct increase in size as the incubation period advances. The average incubation period is 28 days, the minimum and maximum being 26 and 34 days respectively ; practically all the eggs hatch, the only exceptions being when the soil becomes either too dry or too moist.

The Larva or White Grub.

The grubs on first emerging (Plate I. ; Fig. 2) from the eggs are greyish white in colour, but within a few hours they acquire their normal colouring. The full grown grub (Plate I. ; Fig. 3) measures slightly more than an inch in length and about a quarter of an inch in breadth ; the whole body is deeply wrinkled and is creamy white in colour with the exception of the last segment which appears greyish black as a result of the contents of the alimentary canal showing through the skin. The head and most of its appendages are reddish orange and the legs and stigmata (breathing pores on the body) are pale clay yellow ; the body is sparsely clad with hairs.

The great majority of the grubs are found within six inches of the surface of the soil and, although pits have been dug to a depth of six feet at different seasons of the year, no grubs have ever been found below the twelve inch mark. Speaking generally, the grubs in a cane field occur most commonly under the cane stools but they can also be found between the rows. The grubs are by no means confined to fields growing sugar-cane, for they have been found attacking maize and large numbers have been dug out of fields that have grown no cane for a number of years, the only vegetation on these abandoned lands being a miserably stunted growth of weeds; fields have been allowed to lie fallow for eighteen months and grubs have been just as numerous at the end of the fallow period as at the beginning. The survival of white grubs in fallow lands or in abandoned lands carrying a poor growth of weeds is explained by the fact that their food consists largely of decaying organic matter extracted from the soil which they swallow in large quantities; the suggestion sometimes made that they can be starved out by bare fallowing is therefore useless as a control measure in practical agriculture. Only a small proportion of the food consumed consists of living plant tissue and when it was withheld in a series of laboratory experiments it was found that the absence of living tissue produced no visible effect whatever on the development of the grubs. Unfortunately cane roots form a part of the small proportion of living tissue consumed by the grubs and the latter sometimes occur in such numbers in sandy soils that the result of their activities is a very serious matter; the destruction of the cane roots becomes particularly serious when the grubs are about half or three quarters grown, and in January, February and March, fields of young cane suffer very severely through the destruction of the roots. The young shoots are also often severely attacked at the base, the grubs eating the tissue out to such an extent that the shoots are in many cases partially or completely severed from the root system or the set; the first symptom of attack is the yellowing of the leaves due to the stoppage or reduction of the rate of absorption of soil moisture as a result of the attack on the root system or base of the shoot. Older cane is also attacked and sometimes destroyed but generally the older crops are fairly well able to withstand the attacks of the grubs, and although a reduction in yield results from the activities of the white grubs there is seldom total destruction of the stool in these advanced crops. The duration of the white grub stage is about nine or ten months, this being by far the longest stage in the insect's life cycle.

The Pupa.

When the grub is full grown, which occurs about April or even earlier, it enters what is called the prepupal stage (Plate I.; Fig. 4); at the beginning of this stage the grub ceases feeding and the body shrinks in size until the normally distended segment at the

This species is a native of Fiji, a fact that accounts for the presence of a number of natural enemies ; were it an introduced species that had arrived without its natural enemies, as is the case with the cane beetle borer, the position would be much more serious.

The wireworms of the click beetle, known as *Monocrepidius pallipes,* Esch. (Plate II ; Figs. 1-3) attack the white grubs by seizing them behind the head and puncturing the skin ; through the hole thus formed they extract the tissues of the body. A carefully conducted set of experiments showed that each specimen of this wireworm ate grubs at the rate of 57 per annum, a feeding rate that justifies the investigator in regarding this predator as being of very considerable economic importance. It is always found in sandy soils associated with the white grubs of *Rhopaea vestita,* Arrow, and like its host it has never been found in other types of soil ; unlike the sugar cane wireworm (*Simodactylus cinnamomeus,* Boisd.) it never attacks sugar cane in the field and hence it can be regarded as purely beneficial.

The wireworms of another click beetle, known as *Lacon stricticollis,* Fairm. (Plate II ; Figs. 4-5) similarly attack the white grubs of this species, but as they also attack sugar cane in the field, the benefit derived from their predaceous habits is just about balanced by the damage they do to cane.

The ordinary sugar cane wireworm (*Simodactylus cinnamomeus,* Boisd.) also occasionally eats white grubs in the field, but any good it may do is completely outweighed by the tremendous damage is does to young cane plants.

The large black and yellow wasp known as *Discolia ovalauensis.* Sauss. (Plate III ; Figs. 1 and 2) is an important control factor ; in attacking its prey the wasp burrows into the ground, seizes a grub of suitable size, stings it and thus paralyses it. Once the grub is stung it ceases feeding and moving about in the soil and is so helpless that it cannot rub off the egg that the wasp lays on its abdomen ; this wasp egg hatches out and the maggot emerging from it feeds on the paralysed white grub. The wasp maggot subsequently pupates alongside the body of its host which is now nothing but an empty skin ; the wasp eventually emerges, feeds, mates, and, if a female, repeats the egg laying process. The

The beetle (Plate I.; Fig. 6) is reddish brown in colour and is slightly less than three quarters of an inch in length and about a quarter of an inch in breadth; the sexes can readily be separated by the structure of the antennae (situated on the head), the differences in shape being clearly shown in Plate I., Fig. 7 (male) and 8 (female). The beetles feed on the leaves of the guava, the rain tree, the coconut palm and the sugar cane, but the amount of leaf surface consumed per beetle is very small and it cannot be said that the beetle itself does any damage of importance. Dissections and breeding records show that the female does not lay a large number of eggs, the greatest number obtained so far being 36. The duration of the beetle's life is about two months.

Summary of the Life History.

The life history is summarised in the following sentences. In June and July, or as early as April and as late as October in some cases, the female lays 20 to 30 eggs singly in sandy soil at a depth of 15 to 20 inches and after an incubation period of 28 days the white grubs hatch out and feed on humus and living plant tissue; the grubs are most destructive to sugar-cane in the first three months of the following year, *i.e.*, when they are half or three quarters grown. The grubs are full grown in April and May and after a prepupal stage of two weeks they pupate in an unlined earthen cell at a depth of 6 to 18 inches; the pupal period lasts for 31 days and the beetle formed at the end of that period remains in the pupal cell for a further two weeks, at the end of which period its body has hardened and darkened. It then emerges, feeds and mates, and the female lays eggs, thus repeating the life cycle. A period of about one year is required for the newly laid egg to pass through the various stages that lead to the production of the sexually mature beetle; damage of importance is done in the white grub or larval stage only, the beetle feeding sparingly on the leaves of guava, coconut, rain tree and sugar cane.

Natural Enemies.

The destructive capacity of white grubs when conditions are favourable for their development is very great indeed, but fortunately several natural enemies levy a heavy toll on *Rhopaea vestita*, Arrow, and so damage never reaches the proportions it might otherwise attain, although it is still serious enough in many fields.

insects, this beetle is little attracted by brilliant lights and the only beetles that flew to the lights were males. The capture and destruction of males was practically valueless ; what was wanted was the female before she had laid her eggs.

An attempt was made in 1917 to increase the efficiency of the natural control of this pest by introducing another parasite known as *Scolia manilae,* Ashm. (Plate III ; Fig 3.) ; in its mode of attack it very closely resembles *Discolia ovalauensis,* Sauss., a natural enemy already mentioned in an earlier paragraph. It is also a wasp and the writer was so impressed by its work in Hawaii, where it was introduced by the entomologists of the Hawaiian Sugar Planters' Experiment Station (Messrs. Muir, Swezey, Osborn, Williams and Timberlake were the officers engaged on this work), that he brought a colony to Fiji. A large colony was successfully transported to and liberated in Fiji, but the parasite has not yet been recovered ; it may still establish itself, and after the experience with the cane beetle borer Tachinid parasite (*Ceromasia sphenophori,* Vill.), which is now doing excellent work at Nausori after it had been regarded as a failure, it cannot yet be said that this parasite of the white grub has failed.

II.—The White Grub of Alluvial and Red Hill Soils.

The white grubs of alluvial land and red hill soils belong to two species, namely, *Rhopaea subnitida,* Arrow, and *Adoretus versutus,* Har. ; the species described in the preceding pages has been found in sandy soils only. *Rhopaea subnitida,* Arrow, is the species generally referred to as the white grub of alluvial and red hill soils, although the grubs of *Adoretus versutus,* Har., also occur in both these soil types. The former will be dealt with now but it will be discussed in much less detail than the white grub of sandy soil, partly because it is of less importance, partly because of the similarity of the life histories and partly because it has not been so extensively studied.

Summary of the Life History.

In appearance each stage of this insect's life cycle very closely resembles the corresponding stage of the sandy soil species of white grub ; they are all, however, of slightly larger dimensions than in the sandy soil species. There is no easy way of separating wasps emerge from the soil on bright sunny days only and they can be seen in the forenoon feeding on the honey and pollen in vauvau or bele flowers (*Hibiscus tiliaceus*, L.).

Another enemy is a mite (Plate III ; Figs. 4 and 4a) that attacks the grubs in large numbers in the la boratory, the attacked specimens generally dying before pupation ; in the field the conditions do not seem to be so favourable for the development of the mite and this enemy cannot be considered to be nearly as important as the predaceous wireworms and wasp.

Mynah birds (*Acridotheres tristis*, L.) destroy large numbers of white grubs during cultivation operations and they are undoubtedly of great assistance in controlling the ravages of this pest.

Control Measures.

When fields are known to be badly infested with white grubs it is advisable to delay planting until the end of April, because by that time many of the grubs will have entered the prepupal or pupal stages and so the crop will be free from serious attack until December or even later ; by that time it will be well established and better able to resist the attacks of the white grubs. The one disadvantage of delaying planting till the end of April is the obvious loss involved in missing the good rains and heat of the first four months of the year.

The collection and destruction of beetles and grubs is also of assistance in combating this pest, but with the present labour shortage this method cannot be recommended for this pest, although it is still believed to be an economically sound method for the control of the beetle borer at Labasa ; the white grub position is not sufficiently serious to justify this control measure at the present moment.

The frequent ploughing of infested fields exposes many grubs to destruction by mynahs, but unfortunately an increase in the number of ploughings serves no really useful agricultural purpose in sandy soils and so it cannot be recommended.

During the investigation of the life history of this pest efforts were made to attract and trap the beetles by using powerful headlights from locomotives, but it was found that unlike some other of very slight economic importance. The grubs feed on the germinating eyes and roots of the cane sets and young plants, while the beetles do a certain amount of damage by eating the leaves.

The eggs (Plate IV ; Fig. 5) are laid within a few inches of the surface of the soil and somewhat resemble the eggs of the two species just described except for their smaller size, the length being only one twentieth of an inch. The grubs (Plate IV ; Fig. 6) emerge after an incubation period of 12 to 14 days ; they feed in the upper layers of the soil rarely going deeper than six inches and eventually pupate three or four inches below the surface. The pupa (Plate IV ; Fig. 7) measures about half an inch in length by a quarter of an inch in breadth and somewhat resembles the other pupae except for its much smaller size. The beetles (Plate IV; Fig. 8) are found all the year round, but they seem to be particularly numerous in May and June ; they feed on the leaves of sugar cane, guava, rose and cacao. Fortunately this species cannot be considered to be of decided economic importance and control measures are really unnecessary.

the egg stage in the two species (Plate IV; Fig. 1), but the grubs (Plate IV; Fig. 2) can be distinguished by the fact that in the sandy soil species they are smaller, less hairy and shorter legged; the grubs of the sandy soil species seem to be much more liable to injury in handling and in the laboratory the mortality rate is distinctly higher than in the other species. The pupae (Plate IV; Fig. 3) cannot be readily separated, but the beetles (Plate IV; Fig. 4) can be easily distinguished by the disposition of the hairs and punctures on the dorsum or upper surface of the last segment of the abdomen; his is left exposed by the wing covers and in the alluvial soil species this segment (known as the pygidium) has hairs and small punctures, like indentations made by the point of a pin, scattered all over its surface. The hairs and punctures in the other species are more numerous but they are entirely confined to the sides of the segment, thus leaving a smooth median area destitute of hairs and punctures; the presence or absence of this smooth median area serves to distinguish the two beetles.

The eggs are laid about the same time of the year as the eggs of the sandy soil species and the grubs hatch out after an incubation period of 25 days; the grubs feed until April of the following year when pupation starts. The pupal period averages 33 days, followed by a resting stage of two or three weeks, after which the beetle leaves the soil and feeds and mates; the two species are similar in feeding habits and egg laying capacity.

Control Measures.

The natural enemies of this species have not yet been studied; the control measures recommended for the sandy soil species would be equally applicable to the white grub now under discussion. The amount of damage done by this species is not extensive, and in the writer's experience there has been only one instance of it killing well established cane; the case in question occurred at Veisaru, in the Rarawai district, the amount of cane destroyed being quite considerable.

III.—The Rose Beetle.

The white grubs of the rose beetle, *Adoretus versutus*, Har. (Family RUTELIDAE) are frequently found in all types of soil on the sugar cane plantations; the damage they cause is, however,

EXPLANATION OF PLATES.

(The small sketches in each case indicate the natural size of the different stages of the insect, and the small figures the degree of enlargement).

PLATE I.—Illustrating the **white grub of sandy soils** (*Rhopaea vestita,* Arrow). Eggs (Fig. 1) ; newly hatched grub (Fig. 2) ; full grown grub (Fig. 3) ; grub in prepupal stage (Fig. 4) ; pupa (Fig. 5) ; beetle (Fig. 6) ; antenna of male beetle (Fig. 7) ; and antenna of female beetle (Fig. 8).

PLATE II.—*Monocrepidius pallipes,* Esch. ; larva or " **wireworm** " (Fig. 1) ; enlargement of terminal segment of larva (Fig. 1a) ; pupa (Fig. 2) ; and beetle (Fig. 3). *Lacon stricticollis,* Fairm. ; larva (Fig. 4) ; enlargement of terminal segment of larva (Fig. 4a) ; and beetle (Fig. 5). Both these " Wireworms " are predaceous on the white grub of sandy soils.

PLATE III.—The **wasps** illustrated in Figs. 1 and 2 are the female and male respectively of *Discolia ovalauensis,* Sauss., a parasitic enemy of the white grub. Fig. 3 shows the female of the introduced *Scolia manilae,* Ashm., and Figs. 4 and 4a illustrate a native **mite** that attacks the white grub.

PLATE IV.—Figs. 1, 2, 3, 4 and 4a illustrate the eggs, larva, pupa, beetle and the antenna of a male beetle respectively of *Rhopaea subnitida,* Arrow (the **white grub** of **alluvial** and **red hill** soils) ; Figs. 5, 6, 7, 8 and 8a show the eggs, larva, pupa, beetle and the antenna of a beetle of *Adoretus versutus,* Har. (the **Rose Beetle**).

(For **Plates** see pages 14 &c.)

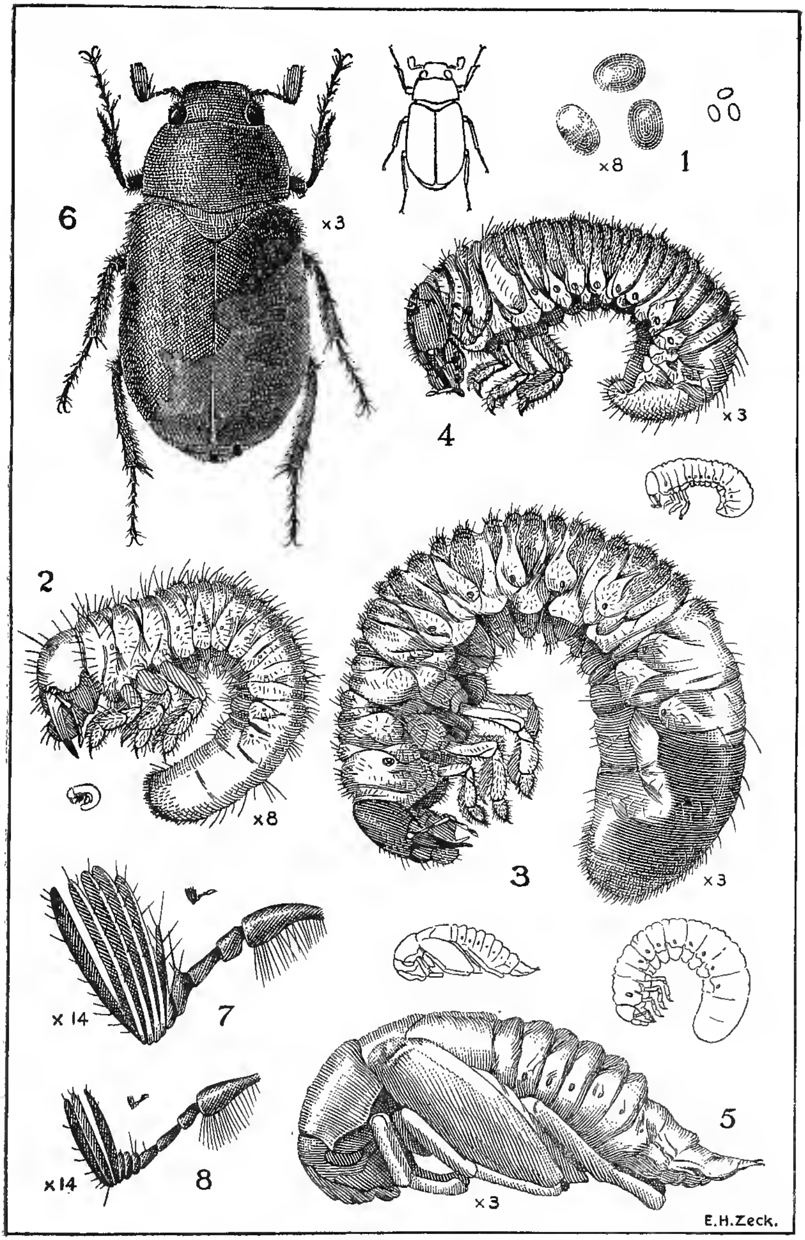

PLATE I (for explanation see page 14.)

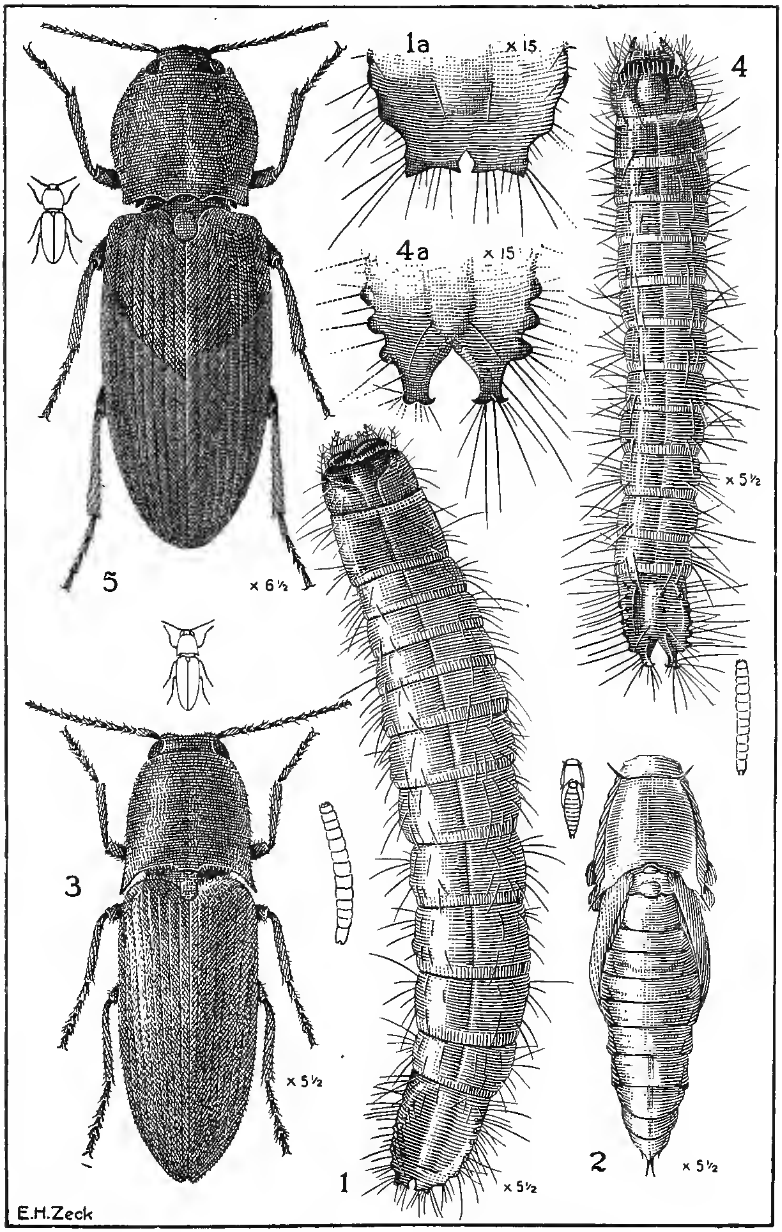

PLATE II (for explanation see page 14.)

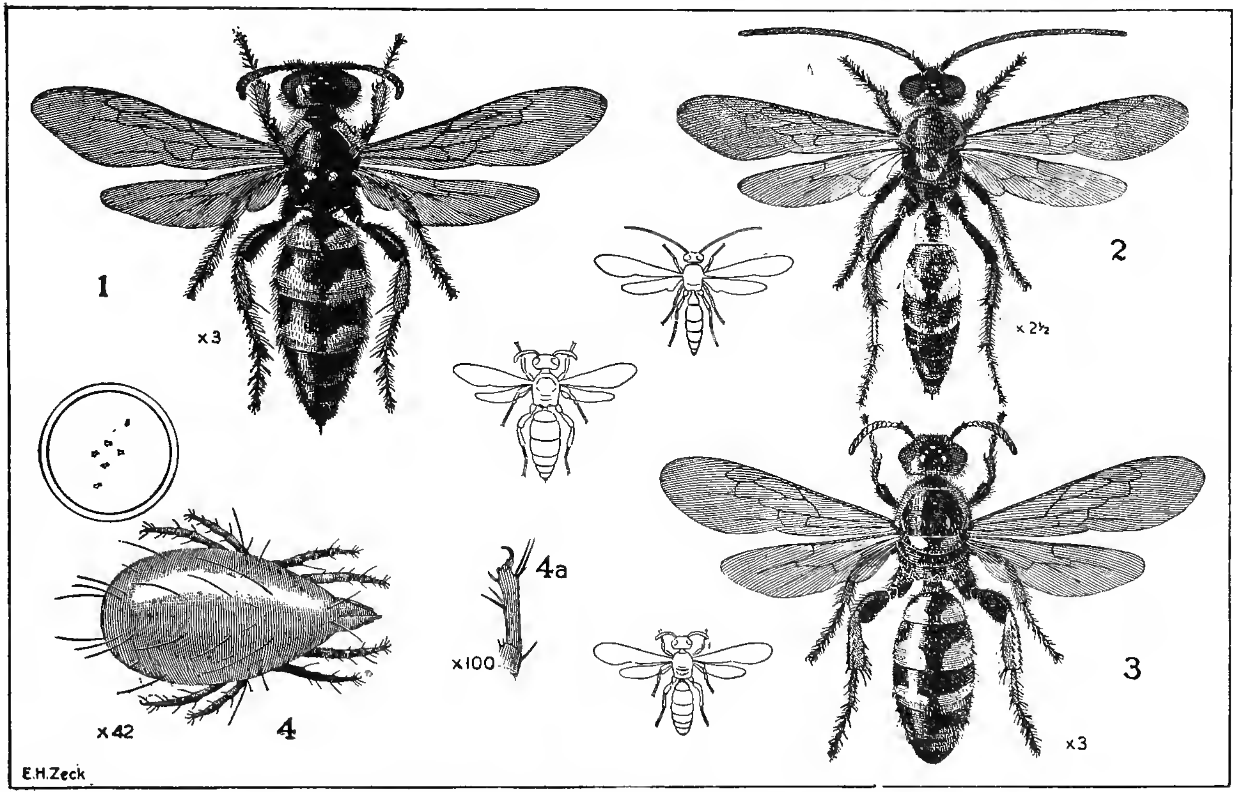

PLATE III (for explanation see page 14.)

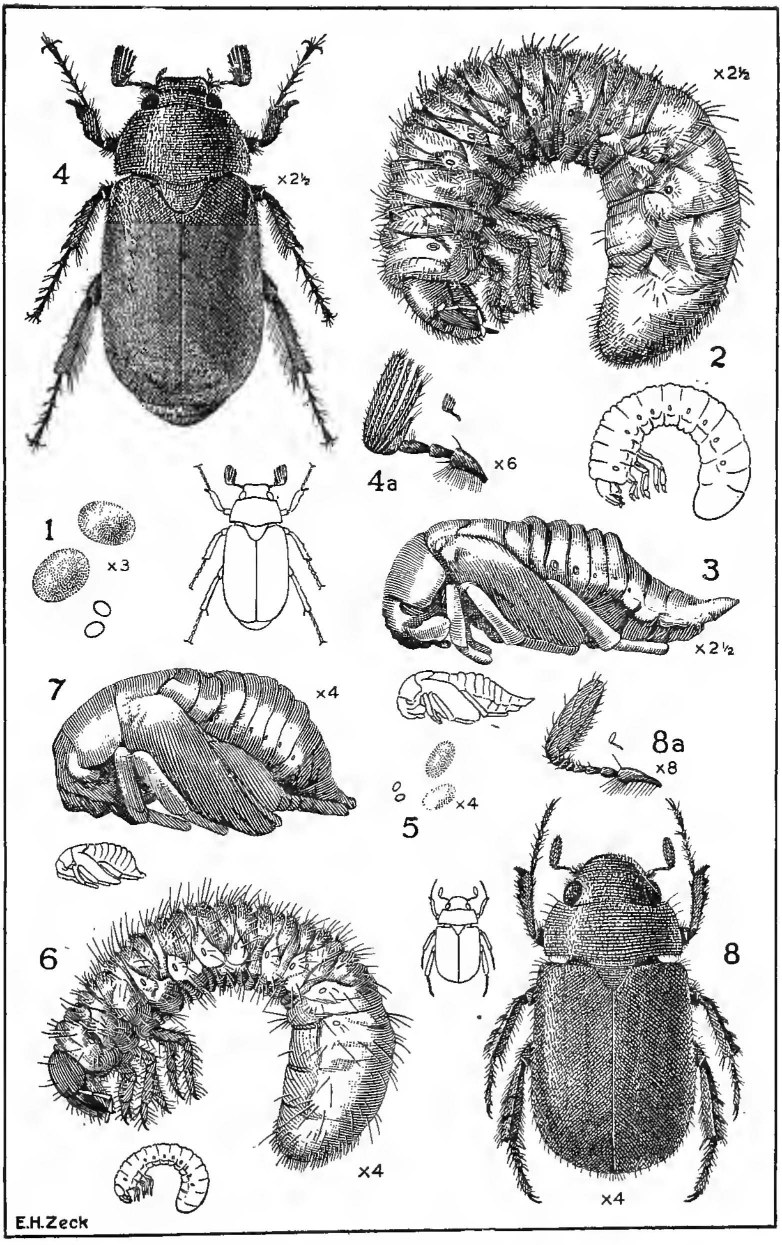

PLATE IV (for explanation see page 14.)